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EVALUATING THE IMPACT OF FERTILIZER TREATMENTS ON GROWTH PERFORMANCE OF SINGLE-CUT FORAGE SORGHUM VARIETIES

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SUMMARY

Sorghum [*Sorghum bicolor* (L.) Moench], a drought-tolerant crop, holds promise for addressing these feed challenges due to its high yield potential and adaptability to arid conditions. This study examines the effect of varying fertilizer treatments on the growth parameters of two single-cut sorghum varieties, HJ 541 and Duggi, under the semi-arid conditions of Hisar, India, during the 2022 *Kharif* season. A factorial randomized block design (RBD) was employed with seven fertilizer levels, including a 150% recommended dose of fertilizer (RDF), and analyzed across parameters such as plant height, leaf count, fresh and dry biomass, and days to 50% flowering. Results demonstrated that HJ 541 consistently outperformed Duggi in all growth parameters, with optimal results observed at 150% RDF, which was statistically equivalent to 100% RDF for specific traits. The findings underscore the importance of tailored fertilizer application in maximizing sorghum's growth potential, providing critical insights into addressing India's forage deficit and enhancing livestock productivity.

Key words: Sorghum, forage crops, fertilizer management, growth parameters, RDF, animal feed

India is home to 536.7 million livestock population, (GOI, 2022), but the country faces a persistent challenge in meeting its feed demands. Despite having one of the largest herds globally, India's livestock productivity remains among the lowest, primarily due to inadequate feed availability. Sorghum [*Sorghum bicolor* (L.) Moench], a member of the Poaceae family, is a drought-tolerant, versatile crop with immense potential to address feed shortages. Commonly known as jowar, sorghum is primarily cultivated for ethanol production, grain, and animal fodder (Devi *et al.*, 2018). It is the fourth most important cereal crop globally, after wheat, rice, and maize, and is often referred to as the "king of millet." Sorghum is a staple food for over 300 million people in semiarid tropical regions and is widely grown in Africa, China, the United States, Mexico, and India. It is particularly valued in India as a high-yielding, nutritious fodder crop that is well-adapted to arid and semi-arid regions. Sorghum fodder contributes 20-45% of the total dry feed for dairy cattle during regular seasons and up to 60% during lean summer and winter months (Jain and Patel, 2013). The crop's resilience, including its short growing period and tolerance to salinity and drought, makes it a reliable option for regions with scarce resources.

Over the past three decades, sorghum's role in animal nutrition has grown significantly. It is now recognized globally as a "smart crop" because it provides food, feed, fodder, and fuel with minimal inputs, particularly in water-stressed regions (Tonapi *et al.*, 2011). Additionally, sorghum is used for silage and hay production, ensuring consistent milk output during fodder-scarce periods (Iqbal *et al.*, 2015). As a multipurpose crop, it is utilized for human consumption, as construction materials, for brooms, and as animal feed, further enhancing its value (Rooney and Waniska, 2000).

Success of sorghum cultivation depends on proper fertilization and selecting suitable cultivars (Anil *et al*., 2024). Efficient fertilizer management in fodder crops enhances forage quality, preserves soil health, and optimizes herbage yield per unit area and time. Among nutrients, nitrogen (N) plays a pivotal role, followed by phosphorus (P) and potassium (K). While chemical fertilizers have significantly boosted crop production, a balanced nutrient supply is essential for sustainable agriculture (Kaloo, 2003). Overreliance on cropping without adequate potassium (K) supplementation can lead to long-term nutrient deficiencies. Balanced application of N, P, and K fertilizers is critical under moisture-stress conditions, as it enhances yield potential (Asghar *et al*., 2010). Nutrient interactions, particularly between nitrogen (N) and phosphorus (P), are crucial for fertilizer efficiency and crop response (Aulakh and Malhi, 2004).

Recently, high-yielding single-cut sorghum cultivars have been developed to enhance fodder production. Research has demonstrated that these cultivars achieve their full genetic potential for green fodder production only when supplied with adequate nutrients (Kumar and Chaplot, 2015). However, knowledge gaps persist regarding the response of newly developed genotypes to varying levels of fertility. Evaluating these responses is crucial for optimizing fertilizer management practices and achieving maximum productivity (Rana *et al*., 2013). Poor adoption of improved genotypes and agronomic practices, including weed control, plant protection, and irrigation, has led to significant losses in fodder sorghum productivity, with reductions of 39, 33, 31, 30 and 22 per cent, respectively, compared to the adoption of complete agronomic packages (Satpal *et al*., 2021). Identifying location-specific production technologies and high-quality sorghum genotypes can significantly enhance fodder availability and livestock nutrition, contributing to a potential "white revolution" in milk production (Singh and Sumeriya, 2012). Hence, in the study, we have investigated the effect of different fertilizers on the growth of forage sorghum.

MATERIALS AND METHODS

The present research was conducted at the Forage Section Research Farm, CCS Haryana Agricultural University, Hisar, Haryana, during the 2022 *Kharif* season. Hisar is located at 29.090°N latitude and 75.43°E longitude in Western Haryana. It has an average elevation of 215.2 m above mean sea level. The details of materials and methods carried out in the present investigation are as follows:

Climate and weather conditions

Hisar is situated on the outer margins of the Southwest monsoon region, characterized by a semi-arid and subtropical climate with hot, dry winds during the summer months. The summers are short and sweltering, and winters are cool and dry. The mean weekly meteorological data recorded during the 2022 crop season at the meteorological observatory of CCS Haryana Agricultural University, Hisar, are presented in Fig. 1. During the crop growing period, the weekly highest and lowest mean temperatures recorded were 39.8 °C and 20.5 °C in the 2nd and 17th crop weeks, respectively. The weekly mean lowest and highest relative humidity recorded were 68% and 95.0% in the morning, with the 2nd and 7th standard weeks, and 43% and 83% in the evening, with the 2nd and 7th standard weeks, respectively. The data indicated that the total rainfall received during the crop-growing period was 98.5 mm.

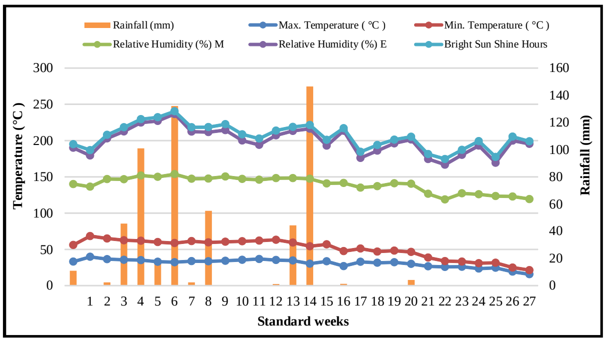

Fig. 1. Mean weekly meteorological data during the summer season (2022).

Soil composition of the field

Before sowing the crop, soil samples were collected from a depth of 0-15 cm and analysed for their mechanical, physical, and chemical properties, as well as to determine the soil moisture content shown in Table 1.

Varieties and treatment details

In this study, two single-cut sorghum varieties, namely HJ 541 (a Popular variety released

TABLE 1

Physico-chemical properties of soil in the field before sowing

S. No.	Particulars	Results	Method used
1.	Soil texture	Sandy Loam	Bouyoucos hydrometer method (Piper, 1966)
2.	Soil pH value (1:2.5 soil: water)	7.75	Glass electrode PH meter method (Jackson, 1973)
3.	EC (dS/m)	0.38	Conductivity bridge method (Richards,1954)
4.	Soil organic carbon (%)	0.46	Partial oxidation method (Walkley and Black, 1934)
5.	Available Nitrogen (kg N/ha)	133.5	Alkaline permanganate method (Subbiah and Asija, 1956)
6.	Available Phosphorus (kg P/ha)	12.5	Sodium bicarbonate method (Olsen *et al.*, 1954)
7.	Available Potassium (kg K/ha)	245.4	Neutral NH4 acetate method (Jackson, 1973)

by CCS HAU, Hisar) and Duggi (a local variety), were used to investigate the effect of different fertilizer doses on selected parameters. The experiment was laid out in a factorial Randomized Block Design (RBD), with two varieties as factor A and seven fertilizer doses as factor B, resulting in 14 treatment combinations and three replicates, totalling 42 plots. The number of replications was three, and the plot size was 3 m × 5 m. The treatments were T_1: Control (Without any fertilizer treatments), T_2: 50% RDF, T_3: 100% RDF (75 kg N +30 kg P_2O_5 +30 kg K_2O), T_4: 150% RDF, T_5: 100% RDF minus N (30 kg P_2O_5 +30 kg K_2O), T_6: 100% RDF minus P (75 kg N+30 kg K_2O) and T_7: 100% RDF minus K (75 kg N +30 kg P_2O_5).

RESULTS AND DISCUSSION

The results revealed that, compared to Duggi, HJ 541 attained the maximum plant size, the highest number of leaves per plant, the maximum fresh weight, the maximum dry matter per plant, and a more extended period to reach 50% flowering height at all stages.

Plant population (metre^{-1} row length)

The plant population of the two varieties ranged from 10.90 to 11.12, with a value of 11.12 for HJ 541. The plant population under various fertilizer levels ranged from 9.92 to 12.17, with a maximum of 150% RDF (12.17), as shown in Figure 2. The variety and fertilizer levels did not have a statistically significant effect on the plant population at harvest. Kaushal *et al.* (2017) and Kaur and Satpal (2019) also reported similar results. This study obtained the maximum plant population at 150% RDF. Similar results were also observed by Yonter *et al.* (2022).

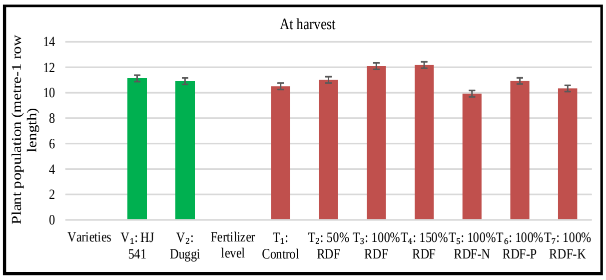

Fig. 2. Effect of different fertilizer levels on the plant population of sorghum varieties at Harvest.

Number of leaves per plant

Compared to Duggi, variety HJ 541 recorded the maximum number of leaves per plant: 5.43, 6.95, 10.71, and 12.95 at 20, 40, and 60 DAS and harvest, respectively. The maximum number of leaves per plant in both varieties at all the stages of growth was obtained at 150% RDF level 6.83, 9.00, 12.50, and 14.67 at 20, 40, 60 DAS, and harvest, respectively, which was at par with the 100% RDF level at all the stages shown in Fig. 3. The data on several leaves per plant revealed that variety and fertilizer levels statistically affected the number of leaves per plant at 20, 40, and 60 days after sowing (DAS) and at harvest, respectively. A similar pattern in the number of leaves of genotypes was reported by Gurjar *et al.* (2019). The report of a maximum number of leaves per plant was at a 150% RDF level at 20, 40, and 60 DAS, as well as at harvest. This study followed a similar trend to previously reported studies (Afzal *et al.*, 2012; Talpada *et al.*, 2016; Nirmal *et al.*, 2016).

Plant height (cm)

The data on plant height at various stages of plant growth under different fertilizer levels are presented in Table 2. The heights of the higher plants (cm) were recorded at 20, 40, and 60 days after sowing

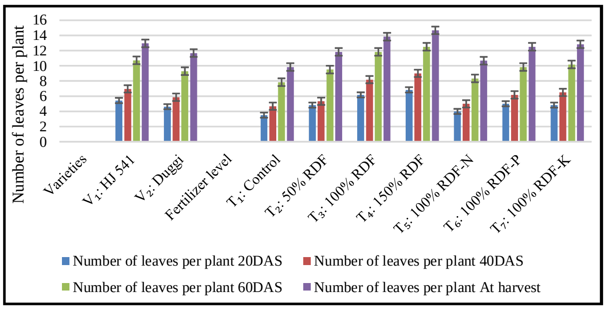

Fig. 3. Effect of different fertilizer levels on the Number of leaves per plant of sorghum varieties at different stages.

(DAS) and at harvest for varieties HJ 541 and Duggi, as follows: 33.11, 89.32, 140.66, and 236.41. The variation in plant height of the genotype might be related to inherent differences and their high vigor (Kumar and Chaplot, 2020). A similar difference in the plant height of genotypes was also reported earlier (Shanti *et al*., 2019; Singh *et al*., 2021). The higher plant height was recorded at 150% RDF levels of 35.25, 95.25, 150.00, and 252.0 at 20, 40, and 60 DAS, and harvest, respectively, comparable to the 100% RDF level at 60 DAS and at harvest. Similar results are also reported by Meena *et al*. (2020) and Adhikari *et al*. (2021).

TABLE 2

Effect of different fertilizer levels on plant height of sorghum varieties

Varieties	Plant height (cm)			
	20 DAS	40 DAS	60 DAS	At harvest
V_1: HJ 541	33.11	89.32	140.66	236.41
V_2: Duggi	26.57	74.04	121.72	209.45
SE(m) ±	0.13	0.20	0.22	1.20
SE(d)	0.28	2.95	0.31	1.70
CD at 5%	0.38	0.58	0.65	3.52
Fertilizer level				
T_1: Control	23.25	66.00	109.50	190.08
T_2: 50% RDF	28.38	79.00	128.78	215.50
T_3: 100% RDF	34.25	93.00	148.95	247.62
T_4: 150% RDF	35.25	95.25	150.00	252.05
T_5: 100% RDF-N	25.00	69.75	113.88	198.58
T_6: 100% RDF-P	30.50	83.00	132.00	226.08
T_7: 100% RDF-K	32.25	85.75	135.25	230.58
SE(m) ±	0.24	0.37	0.42	2.25
SE(d)	0.52	5.51	0.59	3.19
CD at 5%	0.71	1.08	1.21	6.59
V x F				
SE(m) ±	0.34	0.52	0.59	3.19
SE(d)	0.74	7.80	0.83	4.51
CD at 5%	NS	1.53	1.71	9.32

Fresh weight per plant (g)

The data on fresh weight per plant at different stages of plant growth under various treatments are presented in Table 3. The maximum fresh weight per plant (g) was 12.31, 39.63, 164.15, and 277.31 at 20, 40, and 60 DAS and at harvest, respectively, for variety HJ 541, compared to Duggi. The maximum fresh weight per plant in both varieties was obtained at 150% RDF levels, precisely 16.15, 50.50, 221.30, and 353.67 at 20, 40, 60 DAS, and harvest, respectively, which was comparable to the 100% RDF level at 60 DAS and harvest.

TABLE 3

Effect of different fertilizer levels on Fresh weight per plant of sorghum varieties

Varieties	Fresh weight per plant (g)			
	20 DAS	40 DAS	60 DAS	At harvest
V_1: HJ 541	12.31	39.63	164.15	277.31
V_2: Duggi	11.38	32.13	143.59	237.78
SE(m) ±	0.04	0.47	2.20	3.22
SE(d)	0.06	0.66	3.11	4.56
CD at 5%	0.12	1.36	6.44	9.42
Fertilizer level				
T_1: Control	8.77	22.12	70.05	162.60
T_2: 50% RDF	12.28	35.25	145.13	262.68
T_3: 100% RDF	13.92	46.40	210.92	338.85
T_4: 150% RDF	16.15	50.50	221.30	353.67
T_5: 100% RDF-N	9.23	27.00	120.22	208.37
T_6: 100% RDF-P	10.08	31.88	137.80	223.65
T_7: 100% RDF-K	12.47	38.02	171.65	253.00
SE(m) ±	0.08	0.87	4.12	6.03
SE(d)	0.11	1.23	5.83	8.52
CD at 5%	0.22	2.54	12.04	17.61
V x F				
SE(m) ±	0.11	1.23	5.83	8.52
SE(d)	0.15	1.74	8.24	12.05
CD at 5%	0.32	NS	17.03	NS

Dry matter per plant (g)

Table 4 presents the data on dry matter per plant at various growth stages under different fertilizer levels. The maximum dry matter per plant (g) was 3.26, 6.95, 49.03, and 73.78 at 20, 40, and 60 days after sowing (DAS), and at harvest, it was recorded for variety HJ 541 compared to Duggi. The maximum dry matter per plant in both varieties was obtained at 150% RDF levels, precisely 3.88, 9.74, 62.60, and

TABLE 4

Effect of different fertilizer levels on dry matter per plant of sorghum varieties

Varieties	Dry matter per plant (g)			
	20 DAS	40 DAS	60 DAS	At harvest
V_1: HJ 541	3.26	6.95	49.03	73.78
V_2: Duggi	2.48	6.00	39.84	63.65
SE(m) ±	0.04	0.08	0.63	0.77
SE(d)	0.06	0.11	0.89	1.09
CD	0.12	0.22	1.84	2.25
Fertilizer level				
T_1: Control	1.83	3.67	19.48	46.14
T_2: 50% RDF	2.63	6.05	40.66	69.13
T_3: 100% RDF	3.38	8.15	59.40	86.24
T_4: 150% RDF	3.88	9.74	62.60	90.15
T_5: 100% RDF-N	2.40	4.91	37.78	61.04
T_6: 100% RDF-P	2.80	5.79	42.75	60.17
T_7:100% RDF-K	3.20	6.99	48.38	68.14
SE(m) ±	0.08	0.14	1.18	1.44
SE(d)	0.11	0.20	1.67	2.04
CD	0.22	0.41	3.45	4.21
VxF				
SE(m) ±	0.11	0.20	1.67	2.04
SE(d)	0.15	0.28	2.36	2.88
CD	NS	0.58	4.88	5.96

90.15 at 20, 40, 60 DAS, and harvest, respectively. This was comparable to the 100% RDF level at 60 DAS and harvest.

The fresh weight and dry weight per plant revealed that variety and fertilizer levels statistically affect fresh weight per plant at all stages, with maximum fresh weight and dry weight at 150% RDF level. Similar reports have also been made earlier (Satpal *et al*., 2019; Satpal *et al*., 2020; Kumar and Chaplot, 2020; Kumar *et al*., 2022). Higher doses of fertilizer resulted in higher availability of N and accelerated the process of cell division, enlargement, and elongation. This, in turn, resulted in luxuriant vegetative growth, leading to higher yields of green forage. Similar results have been reported in earlier studies (Sanmugapriya and Kalpana, 2017; Mishra *et al.*, 2017; Crawford *et al.*, 2018; Rewatkar *et al.*, 2022; Mopagar *et al*., 2023).

Days to 50% flowering (harvesting stage)

The highest days to 50% flowering (84.10) were obtained with variety HJ 541, compared to Duggi. The highest days to 50% flowering were recorded at

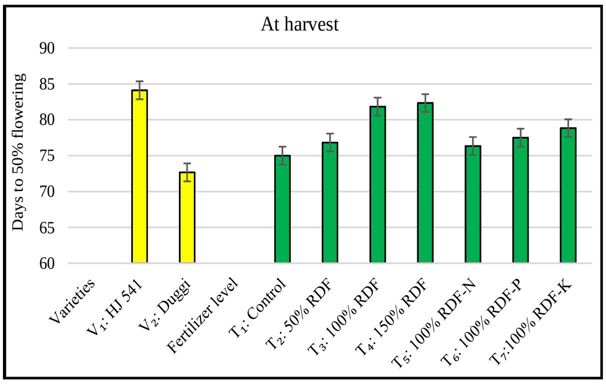

Fig. 4. Effect of different fertilizer levels on Days to 50% flowering of sorghum varieties.

an 82.33% RDF level, which was comparable to the 100% RDF level shown in Fig. 4. According to earlier reports (Thakare *et al*., 2020; Bhutada *et al*., 2020), fertilizer levels have been found to affect the number of days to 50% flowering significantly. This may be attributed to a better nutritional supply, *i.e*., lower nutritional stress, compared to early flowering in nutritionally deficient conditions with a lower fertilizer supply. Similar results are shown by Sujathamma *et al*. (2015) and Satpal *et al*. (2019).

CONCLUSION

This study highlights the significant impact of fertilizer levels on the growth performance of single-cut forage sorghum varieties. The HJ 541 variety exhibited superior growth metrics across all parameters compared to Duggi, showcasing its potential as a high-yielding forage crop. The application of 150% RDF yielded the best results, but 100% RDF also performed comparably well, suggesting its practicality for sustainable and cost-effective forage production. These findings advocate for improved fertilizer management practices and high-yielding genotypes, such as HJ 541, to address India's green and dry forage deficit, thereby contributing to enhanced livestock nutrition and productivity.

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